

Comprehensive Verification Report on Structural Bottlenecks in the Global Supply Chain: Resource Competition Between Food Security and AI Infrastructure

1. General Overview and Evaluation of the Original Draft

This report rigorously verifies and expands upon the hypotheses presented in the original draft, "Should Gas Turbines Be Used for Food or AI?". It examines the prolonged global fertilizer crisis caused by the destruction of infrastructure in the Persian Gulf, the monopolization of gas turbines by AI data centers, Japan's quasi-monopolistic position in the supply chain of single-crystal turbine blades and superalloys, and the structural limits of AI business models. The analysis is conducted through the lens of the latest market data, geopolitical trends, technical constraints, and legal frameworks.

To conclude, the macroeconomic and geopolitical core thesis of the original draft—that "the expansion of AI compute resources is causing physical resource competition, consequently delaying the restoration of global food production infrastructure"—is highly accurate and strikes at the most severe paradox facing the current global market. The majority of the draft's claims are strongly corroborated by various energy research institutions and market data.

However, the micro-level manufacturing description in the draft, which states that they are "competing for order on the exact same production line of the exact same manufacturer," requires minor technical correction regarding the exact location of the bottleneck, based on the technical differences between aeroderivative turbines and heavy-duty turbines. This report delves deeper into the context of the original draft, providing comprehensive analysis on the collapse of the AI industry's profit structure, environmental regulatory evasion by companies like xAI, the legal battles surrounding Anthropic's military use, and how the Japanese government could intervene using the "Economic Security Promotion Act."

2. Destruction of the Fertilizer Supply Chain and the Structure of the Global Food Crisis

The prospect of the Strait of Hormuz reopening following the ceasefire agreement with Iran in April 2026 brought temporary relief to the crude oil market. However, as the original draft

correctly points out, the physical unblocking of the strait does not mean destroyed production infrastructure will immediately recover. The Persian Gulf region is not merely a transit point for energy; it plays a decisive role as a "fertilizer synthesis hub" supporting global agriculture.

2.1 Overwhelming Share in Persian Gulf Fertilizer Production

The Persian Gulf countries form the heart of the global fertilizer trade, utilizing abundant natural gas and byproducts obtained from the oil refining process. Approximately 30% of globally traded raw fertilizer materials transported by sea pass through this region, and a long-term supply disruption directly leads to a severe food crisis.¹

Specifically, the region accounts for 46% of the global export trade of urea, the world's most widely used nitrogen fertilizer.⁴ Furthermore, the region accounts for 29% of ammonia (the foundation of nitrogen fertilizers), 26% of diammonium phosphate (DAP), and 13% of monoammonium phosphate (MAP) exports.¹ As for sulfur, an essential raw material for the sulfuric acid required in phosphate fertilizer production, the region supplies nearly 50% of the global trade.¹

| Fertilizer Type/Raw Material | Persian Gulf Global Export Share | Major Affected Countries and Scale of Impact |
|------------------------------|----------------------------------|--|
| Urea | 46% | India (18%), Brazil (10%). Directly leads to soaring agricultural production costs. ⁴ |
| Ammonia | 29% | South Korea, Morocco, Japan. Directly affected by LNG facility destruction as it uses natural gas as feedstock. ¹ |
| Sulfur | Approx. 50% | Global. Ripples through the entire phosphate fertilizer (MAP/DAP) value chain, creating production halt risks. ¹ |

2.2 Bombardment of the Ras Laffan Industrial City and Prolonged Restoration

Retaliatory attacks by Iran dealt a devastating blow to the LNG trains (S4 and S6) and the Pearl GTL (Gas-to-Liquids) facility located in Qatar's Ras Laffan Industrial City.⁶ This attack instantly

wiped out 17% of Qatar's LNG export capacity (equivalent to roughly 12.8 million tons annually).⁶

The original draft's assertion that "repair will take 3 to 5 years" aligns perfectly with the analyses of energy research firms like Rystad Energy and Wood Mackenzie.⁶ The Pearl GTL facility houses ultra-low temperature Air Separation Units (ASUs) and large heavy-duty gas turbines required to drive massive refrigeration compressors. The damage to these critical components has hopelessly delayed recovery.⁶ While the total infrastructure damage is estimated to be at least \$25 billion, the core issue is not financial capacity, but the rigidity of the supply chain making it physically impossible to procure replacement large gas turbines.⁶

A prolonged shortage of fertilizer supply will deal a catastrophic blow to agriculture in Africa and South Asia. Historically, during the 2022 price spikes, fertilizer use in Africa plummeted by 25%, drastically reducing crop yields.¹ Currently, there are concerns about declining yields of nitrogen-intensive crops (such as rice and wheat). While there are movements to revert to coal-based ammonia production as an alternative—as seen in China, where it currently accounts for 70-80% of production—this runs entirely counter to climate change mitigation efforts.¹

3. Oligopoly Structure and Price Surges in the Gas Turbine Market

The greatest barrier preventing the restoration of destroyed fertilizer and LNG infrastructure is the extreme oligopoly of the gas turbine manufacturing market and an unprecedented backlog of orders.

3.1 "Triopoly" in the Global Market

The heavy-duty gas turbine industry is dominated by a very small number of companies due to enormous capital requirements, high technical barriers, and strict performance and safety standards. The original draft's expression that there are "only three manufacturers in the world" accurately captures the reality of the market.

According to 2025 data, the top players in the gas turbine market are GE Vernova (US), Siemens Energy (Germany), Mitsubishi Heavy Industries (Japan), Baker Hughes, and Wärtsilä, which together account for 38% of the global market share.¹⁰ Particularly in the heavy-duty gas turbines used for LNG facilities and large-scale power generation, GE Vernova, Siemens Energy, and Mitsubishi Heavy Industries boast overwhelming technical superiority. In the market for gas-fired power plants currently under construction (especially in Asia, which accounts for 60% of demand), they form a de facto "triopoly," with GE Vernova holding 38%, Mitsubishi Heavy Industries 17%, and Siemens Energy 16%.¹²

3.2 Unprecedented Demand Excess and 195% Price Surge

Even before the outbreak of the war, the production capacity of these major manufacturers

had reached its absolute limit. As of the end of 2025, the global gas turbine order backlog had reached approximately 110 gigawatts (GW), far exceeding the industry's total annual manufacturing capacity (60-70 GW).¹³

Due to this structural supply shortage, gas turbine prices have surged by 195% compared to 2019 levels and are projected to reach \$600 per kilowatt (kW) by the end of 2027.¹³ Because the turbine itself accounts for 20-30% of the total construction cost of a gas-fired power plant, this price surge has become a fatal financial barrier to infrastructure restoration and new construction.¹⁶ While manufacturers are attempting to expand production capacity, manufacturing constraints on ultra-high-temperature components and a shortage of specially skilled labor mean this supply-demand imbalance is unlikely to be resolved until the 2030s.¹³

4. Physical Limits of Metallurgy: Single-Crystal Blades and Master Ingots

The fundamental reason why gas turbine manufacturing involves a "physical waiting line" lies in the casting process of the "single-crystal turbine blade," the heart of the turbine, exactly as the original draft pointed out.

4.1 The 1600°C Limit and "Directional Solidification Casting"

The thermodynamic efficiency of a gas turbine (the Brayton cycle) improves as the temperature of the combustion gas increases.¹⁷ In modern turbines, the temperature of the gas discharged from the combustor exceeds 1600°C (approx. 3000°F), which surpasses the melting point (approx. 1300-1400°C) of the nickel-based superalloys used for the turbine blades.¹⁸ Furthermore, blades spinning at thousands of revolutions per minute are subjected to immense centrifugal forces and stresses reaching up to 20,000 times the force of gravity.¹⁸

In conventional metal casting, countless microscopic crystals (grain boundaries) form within the metal. Under high temperature and high stress, these boundaries slip, causing the metal to stretch like taffy—a phenomenon known as "creep deformation"—which eventually leads to rupture.¹⁹ To break through this physical limit, modern blades utilize "Directional Solidification" casting, a technology that grows the entire component as a "single giant crystal".¹⁸

Inside the blade, an extremely complex maze of hollow cooling passages (multi-wall serpentine cores) is formed. The rate at which the metal cools and grows as a single crystal is strictly governed by the laws of physics.¹⁸ As the original draft astutely observed, "the physical time for metal to cool and crystallize cannot be shortened with money." Building new casting furnaces and acquiring aerospace-grade quality certification takes at least 2-3 years, and constructing a new factory from scratch takes 4-6 years, making short-term production increases physically impossible.¹⁹

4.2 Technical Correction to the Original Draft: The Structure of

Production Line Competition

Here, a technical correction from an expert standpoint is applied to the original draft's statement: "On the exact same production line of the exact same manufacturer, turbines for AI data centers and turbines for restoring LNG facilities are competing for their turn."

What AI data centers (especially the Stargate and xAI projects detailed below) are ordering in massive quantities are "aeroderivative gas turbines," which adapt aircraft engine designs, such as GE's "LM2500XPRESS".¹⁷ These feature fast startup times and flexible power supply capabilities. On the other hand, the turbines used to drive compressors in massive LNG plants like Ras Laffan, or for large-scale power generation, are "heavy-duty gas turbines," such as the "7HA" or "7F" series.⁶

Because these two types of turbines have completely different blade sizes, heat treatment processes, and operational hold times, their final "assembly lines" and "casting molds" are not entirely identical.²² Casting single crystals for heavy-duty turbines is much more difficult to maintain yield rates for than for smaller aviation-derived blades.²²

However, the original draft's macro-level conclusion that they are "competing" is completely correct. This is because the true bottleneck lies not in the assembly line, but further upstream in the "raw materials."

4.3 The Absolute Dominance of Superalloy Master Ingots

To cast single-crystal blades, "superalloy master ingots" (nickel-based and cobalt-based superalloys) of extremely high purity and strictly controlled composition are indispensable.¹⁹ The market for these master ingots was valued at approximately \$540 million in 2024, and demand is exploding due to rapid growth in the aerospace and power generation industries.²⁸

The original draft points out that "Japan's IHI Master Metal holds a near-monopolistic position." While competitors like Cannon-Muskegon (USA) exist in the market, the quality superiority of Japanese companies is overwhelming.¹⁹ In the highly delicate process of single-crystal casting, even slight impurities or surface oxidation on the ingot can fatally degrade the yield. Japanese companies like IHI Master Metal provide high-purity, high-quality ingots that other manufacturers cannot replicate, dramatically improving the yields for their clients.³⁰ As a result, the single-crystal blade casting factories of GE, Siemens, and Mitsubishi Heavy Industries are practically held by the throat by the supply of master ingots from Japan.

Whether it is an aeroderivative turbine or a heavy-duty turbine, the capacity of the raw master ingots and the special Vacuum Induction Melting (VIM) furnaces used to melt them are drawn from a shared pool. Therefore, a massive influx of orders for small turbines for AI data centers inevitably squeezes the material supply and labor hours available for large turbines intended for LNG restoration. The "waiting line structure" described in the original draft is a cold reality at the most fundamental layer of metallurgy.

5. The "Cornering" of Power Grids and Turbines by AI Infrastructure

The true identity of the 2-4 year order backlog in the gas turbine market is, exactly as the original draft pointed out, the "cornering" of infrastructure by technology companies desperately trying to secure the power required for training and inference of generative AI (Large Language Models).

5.1 The Emergence of Gigawatt-Scale Data Centers and the "Stargate" Project

Since 2023, the construction of AI infrastructure has completely departed from the realm of software, transforming into a massive, heavy-industry sector. There are currently 4,000 data center projects under construction globally, with total investments exceeding \$1.2 trillion.³³

Symbolizing this frenzy is the "Stargate" project, spearheaded by OpenAI, Microsoft, SoftBank, and Oracle.³⁴ Initially planned as a 1.2 GW facility in Abilene, Texas, the project's expansion plans ultimately reached an estimated 5 GW—a scale comparable to the national power grid of a small country.³⁶ Because it is impossible to draw such extraordinary amounts of power from the existing electrical grid, the developer, Crusoe Energy Systems, made the decision to build its own "behind-the-meter" power plants.³⁶

Crusoe ordered 10 units of GE Vernova's aeroderivative gas turbine "LM2500XPRESS" in December 2024, and an additional 19 units in June 2025, attempting to secure a total of approximately 1 GW in power generation capacity.²³ Derived from aircraft engines, these turbines can rapidly ramp up and down output like an airplane throttle, making them optimal for backing up unstable renewable energy and tracking the sudden computational loads of AI.²³

5.2 xAI's Unlawful Turbine Deployment and Environmental/Social Friction

An even more aggressive approach was taken by xAI, led by Elon Musk. At their "Colossus" supercomputer facilities in Memphis, Tennessee, and Southaven, Mississippi, xAI failed to secure sufficient grid connection and resorted to trucking in and operating up to 62 methane gas turbines.⁴⁰

Astonishingly, xAI utilized a legal loophole by classifying these massive turbines as "non-road engines," commencing operations without obtaining environmental permits under the Clean Air Act.⁴⁰ These facilities have the potential to emit 6 million tons of greenhouse gases and 1,300 tons of hazardous air pollutants annually, scattering jet engine-like noise 24 hours a day and severely disrupting the lives of local residents.⁴⁰

Organizations such as the NAACP (National Association for the Advancement of Colored People) and the Southern Environmental Law Center (SELC) prepared for litigation against xAI's

unauthorized operations, and US regulators also deemed it illegal.⁴¹ However, ultimately, the Mississippi Department of Environmental Quality pushed past intense public backlash and granted permission for the operation of 41 permanent gas turbines.⁴³ This is a blatant example of administrative agencies prioritizing the infrastructure expansion of AI companies over the health of local residents and environmental regulations.

This fierce procurement competition among AI companies, driven by a "secure power at any cost" mentality, is exactly what has completely booked up the world's gas turbine manufacturing lines until 2029.¹⁵

6. The Simultaneous Collapse of the AI Business Model and Profit Structure

The perspective presented in the original draft—that "the profit model of AI is simultaneously collapsing"—perfectly captures the structural dilemma of "Infrastructure Gravity" currently facing the AI industry. The AI companies that cornered the gas turbine market are now suffocating themselves due to the skyrocketing energy costs they helped create.

6.1 "Infrastructure Gravity" and the Explosion of Inference Costs

The traditional software industry historically enjoyed gross margins of over 80% and the "infinite scalability" of near-zero marginal costs.⁴⁵ However, generative AI is not software; it is highly capital-intensive and energy-intensive heavy industry (Infrastructure-as-a-Service).⁴⁵

The enormous initial costs for large-scale training (OpenAI projects a staggering \$121 billion in compute spend by 2028) are no longer merely R&D expenses; they have become part of the Cost of Goods Sold (COGS).⁴⁵ Even more severe is "inference"—the running cost incurred every time a user inputs a prompt and the AI generates a response.⁴⁵

A single response on ChatGPT consumes roughly 10 times more electricity than a traditional Google search.⁴⁶ Across a model's entire lifecycle, inference costs will eventually account for 80-90% of total expenses.⁴⁵ The disruption of LNG supply due to the Middle East war, skyrocketing transit tolls in the Strait of Hormuz, and the 195% increase in gas turbine prices caused by the data centers themselves have structurally raised the electricity costs for this inference.¹³

As the original draft points out, if electricity costs continue to rise, the \$20-per-month subscription model will completely collapse.⁴⁷ OpenAI incurred a \$5 billion loss in 2024 and is projected to bleed a cumulative \$44 billion in deficits by the time it expects to achieve profitability in 2029.⁴⁷ If hardware efficiency improvements cannot outpace soaring energy prices, profit margins will face devastating compression.⁴⁵

| AI Infrastructure Economic Reality (2025-2026) | OpenAI | Anthropic |
|--|--|---|
| Estimated Annual Revenue | Approx. \$13 billion | Approx. \$7 billion |
| Enterprise Valuation | Approx. \$300 billion | Approx. \$183 billion |
| Infrastructure Investment and Loss Projections | \$121 billion invested in compute resources by 2028. Projected cumulative deficit of \$44 billion by 2029. ⁴⁵ | Massive compute load required for LLM training/inference. API inference costs are a heavy burden. ⁴⁵ |

6.2 Retreat in Investment: The Collapse of the Stargate Expansion Plan

This financial pressure has already begun to derail real-world projects. In March 2026, Oracle and OpenAI abandoned plans to expand their flagship Stargate data center in Abilene, Texas, from 1.2 GW to 2.0 GW.³⁷ According to Bloomberg reports, this breakdown stemmed from disagreements over financing terms and "frequent changes" to OpenAI's compute demand forecasts.⁴⁹ This is the strongest signal yet that the era of "unbounded ambition" for AI infrastructure is over, as the industry faces the harsh realities of financing limits and demand uncertainty (operating model reality).⁴⁵

6.3 The Collapse of Trust and Legal Brakes

Furthermore, the social and legal environment surrounding AI companies is deteriorating rapidly.

Legal Battles over Military Use: In 2026, a historic legal battle erupted between the AI company Anthropic and the US Department of Defense (Pentagon). Because Anthropic refused to allow its AI software to be used for autonomous lethal weapons or mass surveillance systems, the Trump administration and the Pentagon designated the company as a "supply chain risk," effectively blacklisting it from federal government contracts.⁵⁰ In response, Anthropic filed lawsuits in federal courts in California and Washington D.C., arguing that the action was unconstitutional retaliation against its First Amendment free speech rights and a violation of the Administrative Procedure Act (APA).⁵¹ The court issued a preliminary injunction, criticizing the government's measures as "Orwellian" and an unjust attempt to "cripple" the company.⁵³ This lawsuit has the potential to act as a legal brake against the government forcing AI companies into military cooperation, gradually undermining the premise of an unlimited government procurement market (and the accompanying explosive growth in infrastructure)

for AI companies.⁵⁰

Loss of Prestige Due to the Epstein Files: In addition, the "collapse of trust" pointed out in the original draft is highly severe. Millions of pages of documents related to Jeffrey Epstein (the Epstein Files), released by the US Department of Justice between 2024 and 2025, made headlines worldwide when they revealed the names of tech elites such as Elon Musk (xAI), Bill Gates (major investor in Microsoft/OpenAI), and Larry Summers (former OpenAI board member).⁵⁵ Although legal wrongdoing has not been proven, amidst growing public anger over environmental destruction and power grid monopolization, the moral revulsion toward the industry's top echelon is causing AI companies to rapidly lose political favor and support for infrastructure investment.⁴⁰

7. The Role of the Japanese Government and the "Economic Security Promotion Act"

"The infrastructure required to ask ChatGPT for tonight's dinner menu is physically preventing the restoration of the fertilizer production needed to grow the ingredients for that very dinner." This ironic conclusion from the original draft brilliantly highlights a "Market Failure" where the free market economy is incapable of correctly prioritizing "resources essential for survival (food)" over "commercial speculation (AI)."

If we leave it to the logic that whoever pays first gets the turbines first, the world will face a severe famine. This is where the "political decision" and intervention of the Japanese government, which holds the absolute upstream "chokepoint" of the global supply chain, becomes crucial.

7.1 "Strategic Indispensability" and Control over Master Ingots

Japan occupies a highly unique and powerful position in the resource competition between AI and food. Not only does it host Mitsubishi Heavy Industries as a final product manufacturer of gas turbines, but Japanese companies like IHI Master Metal hold de facto dominance (Strategic Indispensability) over the global supply chain for the "superalloy master ingots" required to create the "single-crystal blades" that serve as the heart of all turbines.¹⁹

Without the ultra-high purity ingots provided by Japanese companies, neither GE Vernova nor Siemens Energy can successfully cast single-crystal blades with a viable yield, making it physically impossible to clear the backlog of orders intended for AI data centers.²¹

7.2 Prioritizing "Food" via the Economic Security Promotion Act

In 2022, Japan enacted the "Economic Security Promotion Act," introducing the concept of "national survival and independence" into the framework of free trade.⁶² The core of this legislation is to allow the government to intervene in supply chains to ensure the stable supply of "Specified Critical Materials" in order to protect citizens' lives from geopolitical risks.⁶²

A critically important fact is that in December 2022, the Japanese government (Ministry of Agriculture, Forestry and Fisheries) officially designated "Fertilizer" as one of the "Specified Critical Materials" under this act.⁶⁶ Japan relies on imports for nearly 100% of its fertilizer raw materials, meaning a disruption in fertilizer supply directly equates to the collapse of Japan's food security.⁶⁷

Therefore, the Japanese government possesses complete legal grounding and a righteous cause to intervene in market mechanisms. Under the Economic Security Promotion Act, the government can utilize administrative guidance or export control frameworks directed at companies like IHI Master Metal and Mitsubishi Heavy Industries.⁶³ Specifically, the government can issue administrative guidelines stating that "in order to restore the global supply chain of fertilizer, which is a Specified Critical Material, the priority for the supply of superalloy master ingots and gas turbine manufacturing lines destined for the repair of LNG and fertilizer plants in the Middle East (heavy-duty turbines) must be set higher than those destined for AI data centers (aeroderivative turbines)."

7.3 Independent Diplomatic Channels with Iran and Japan's National Interest

As suggested at the end of the original draft, unlike the United States and Europe, Japan maintains a unique diplomatic position in the Middle East. Japan has not engaged in military attacks against Iran, and following the ceasefire, Japanese vessels have already resumed navigation through the Strait of Hormuz.⁶⁹

If Japan plays its powerful card (Strategic Indispensability) of "gas turbine material supply" and demonstrates a stance that prioritizes support for Middle Eastern infrastructure restoration above all else, this becomes a tremendous diplomatic lever. Japan could secure preferential long-term supply contracts for LNG and fertilizer from Qatar. Simultaneously, using Japan's vital contribution as a shield, it could secure guarantees from Iran for the safe passage (or exemption/reduction of transit tolls) of Japanese-flagged and related vessels through the Strait of Hormuz.⁶⁹

8. Conclusion

As a result of rigorous verification of the original draft, "Should Gas Turbines Be Used for Food or AI?", we conclude that the macroeconomic structure presented accurately depicts the most dangerous fault line in the current global economy.

The destruction of fertilizer production bases during the Middle East crisis in 2026 has caused a fatal situation requiring 3 to 5 years for repair.⁶ The delay in restoration is not due to a lack of funding, but rather physical constraints: AI companies have cornered the gas turbine market to secure power for their data centers, maxing out manufacturing lines until 2029.¹⁵ Despite the fact that the AI business model itself is collapsing under soaring energy costs and legal/social headwinds⁴⁷, according to the logic of the market economy (early ordering and financial

power), the restoration of life-sustaining food infrastructure will continue to be sacrificed for the expansion of AI compute resources.

The only entities capable of rectifying this distorted resource allocation are the Japanese metallurgical industry—which monopolistically controls the supply of the "superalloy master ingots" that determine turbine performance—and the Japanese government that regulates it.¹⁹ The Japanese government should apply the "Economic Security Promotion Act" and make the political decision to intervene in the delivery sequencing of gas turbine materials under the mandate of securing fertilizer, a Specified Critical Material.⁶³ This would extend far beyond mere international contribution; in the turbulent landscape of the Middle East, it would serve as the ultimate diplomatic weapon to independently establish Japan's energy and food security.

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